The effects of exchange rate variability on international trade: a Meta-Regression Analysis

Ćorić, Bruno; Pugh, Geoffrey Thomas

The effects of exchange rate variability on international trade: a Meta-Regression Analysis

Journal:	*Applied Economics*
Manuscript ID:	APE-06-0661.R1
Journal Selection:	Applied Economics
Date Submitted by the Author:	27-Dec-2007
Complete List of Authors:	Æoriæ, Bruno; University of Split, Economics Pugh, Geoffrey; Staffordshire University, Business School
JEL Code:	F10 - General < F1 - Trade < F - International Economics, F31 - Foreign Exchange < F3 - International Finance < F - International Economics
Keywords:	Meta-regression analysis, Exchange rate variability, International trade, Hedging, Trade promotion

Editorial Office, Dept of Economics, Warwick University, Coventry CV4 7AL, UK

The effects of exchange rate variability on international trade: a Meta-Regression Analysis

Bruno Ćorić and Geoff Pugh*

Abstract

The trade effects of exchange rate variability have been an issue in international economics for the past 30 years. The contribution of this paper is to apply meta-regression analysis (MRA) to the empirical literature. On average, exchange rate variability exerts a negative effect on international trade. Yet MRA confirms the view that this result is highly conditional, by identifying factors that help to explain why estimated trade effects vary from significantly negative to significantly positive. MRA evidence on the pronounced heterogeneity of the empirical findings may be instructive for policy: first, by establishing that average trade effects are not sufficiently robust to generalise across countries; and, second, by suggesting the importance of hedging opportunities - hence of financial development - for trade promotion. For the practice of MRA, we make a case for checking the robustness of results with respect to estimation technique, model specification and sample.

Running Title:

Meta-regression analysis of the trade effects of exchange rate variability

* Corresponding author: Prof. Geoff Pugh, Staffordshire University Business School, Leek Road, Stoke-on-Trent, ST4 2DF, UK. 0044 (0) 1782 4902; geoff@plainfigures.com . Bruno Ćorić, University of Split, Faculty of Economics, Department of Economics, Matice Hrvatske 31, 21000 Split, Croatia.

The effects of exchange rate variability on international trade: a Meta-Regression Analysis

Abstract

The trade effects of exchange rate variability have been an issue in international economics for the past 30 years. The contribution of this paper is to apply meta-regression analysis (MRA) to the empirical literature. On average, exchange rate variability exerts a negative effect on international trade. Yet MRA confirms the view that this result is highly conditional, by identifying factors that help to explain why estimated trade effects vary from significantly negative to significantly positive. MRA evidence on the pronounced heterogeneity of the empirical findings may be instructive for policy: first, by establishing that average trade effects are not sufficiently robust to generalise across countries; and, second, by suggesting the importance of hedging opportunities - hence of financial development - for trade promotion. For the practice of MRA, we make a case for checking the robustness of results with respect to estimation technique, model specification and sample.

1 Introduction

Since the onset of generalized floating, there has been extensive theoretical and empirical investigation into the effects of exchange rate variability on international trade. This issue has also been prominent in policy debate. There is a consensus that exchange rate movements cannot be anticipated and, hence, create uncertainty in international trade. However, the literature gives no such clear guidance on the trade effects of exchange rate variability and uncertainty. Gros (1987), Dhanani and Groves (2001), De Grauwe (1988) and Dellas and Zilberfarb (1993) develop models in which exchange rate variability may have either a positive or a negative impact on trade. Unfortunately, the ambiguous implications of the theoretical literature are not resolved by the empirical literature. The conclusions from the 58 studies analysed below are presented in Table 1. In each case, the recording of negative, no statistically significant effects, positive or not conclusive (studies reporting a combination of the previous three categories) reflects authors' own interpretations of their results.

Table 1: Econometric studies on the trade effects of exchange rate variability (1978-2003)

The largest category, 33 studies, concludes that exchange rate variability exerts an adverse effect on trade.[1] The other 25 studies reach conclusions suggesting that this is not the case. Indeed, six studies report findings that suggest the precise opposite. This range of published results corresponds to the range of possibilities allowed by theory and suggests that the results reported in this literature are unlikely to be driven by publication bias. The theoretical ambiguity in the relationship between exchange rate variability and trade, together with the corresponding non-conclusive nature of the empirical evidence, are likely to reduce the probability that journal editors and authors have systematically favoured studies and results biased in one or other direction or even towards higher levels of statistical significance irrespective of sign.

This paper uses meta-regression analysis (MRA) to make two contributions to the literature on the trade effects of exchange rate variability: to help explain the wide variation of results – ranging from significantly positive to significantly negative effects – in the empirical literature; and to suggest new lines of enquiry. Because of the pronounced heterogeneity in this literature, we focus on the direction and significance of estimated trade effects. Correspondingly, we do not conclude with a representative estimate of the trade effect, as this would be misleading for most particular contexts of concern to policy makers.

[1] Although some studies concluding that the trade effect is negative nonetheless contain some positive results; for example, Stokman, 1995, reports two positive effects and one zero effect among otherwise consistently negative effects.

The work is structured as follows. Section 2 explains how the data was collected and the choice of effect size. Section 3 explains the MRA of the trade effects of exchange rate variability. Section 4 reports and interprets the results. Section 5 concludes.

2 Data and effect size

We used the EconLit data base (period ending March 2003) to identify as far as possible all econometric investigations of the trade effect of exchange rate variability that have been published in refereed economics journals.[2] As is the norm in MRA, we gathered close to but not necessarily the complete population of studies (Rose and Stanley, 2005). EconLit search is a common approach to minimising the influence of poorly designed and/or executed studies (Stanley, 2001). However, this approach on its own was not sufficient to identify the population of relevant papers. On the one hand, key word(s) search may fail to identify important papers that include estimates of the trade effects of exchange rate variability but do so only as a subsidiary theme (e.g., Rose, 2000). Other papers may be overlooked because the key search words are insufficiently comprehensive and/or authors use terminology that differs from the mainstream of the literature. On the other hand, many papers thus identified may not be relevant (e.g., some will be purely theoretical studies) or report no usable effect size. In practice, therefore, we implemented a more flexible strategy. At first, we used our own knowledge of the literature and existing narrative literature reviews to identify the most cited papers. Next, systematic EconLit search added further papers. In addition, still further papers were brought to our attention during the normal process of informal and formal review of this study. Finally we expanded our

[2] The main combinations of key words used were "exchange rate variability", "exchange rate volatility", "exchange rate uncertainty/risk" and "trade effect".

database beyond those papers published in refereed economics journals to include IMF (1984), Akhtar and Hilton (1984) and De Grauwe and Bellfroid (1987), because these were frequently cited in subsequent studies. Altogether, we identified 58 papers, most of which report multiple results. Accordingly, our 58 studies generated 835 observations. For comparison, Table 2 displays the number of studies and corresponding observations together with goodness of fit measures from three respected MRAs in economics.

Table 2: Number of studies and observations in examples of MRA

A summary measure (effect size) has to be chosen:

1. to combine and compare effect sizes among studies, obtain their mean value, and test their differences for statistical significance; and
2. as the dependent variable of the MRA.

We follow Stanley and Jarrell's (1989) recommendation that in economics the t-value of the regression coefficient is the natural effect size. From each result (regression) reported in each study, the t-value of the estimated coefficient measuring the trade effect of exchange rate variability was chosen as the effect size.[3] This exchange rate variability effect size (ERVES) is independent of the units in which variables in different studies are measured and, given the large sample, under the null of no genuine effect approximates the standard normal distribution (Stanley, 2005), which makes it suitable for the statistical analysis outlined in the following section.

[3] Some studies employ more than one measure of exchange rate variability (e.g., by including both current and lagged values). An appendix detailing how the effect size was selected in each such case is available on request. It is excluded here for reasons of length.

3 Meta-regression analysis

3.1 Meta-analysis of the ERVES

835 ERVES were pooled from the 58 collected studies; 52 studies contain more then one estimation of the trade effect of exchange rate variability. The mean ERVES value is -1.31 with standard deviation of 2.93,[4] which by common standards in meta analysis can be characterised as close to a medium (0.5σ) effect size (Stanley, 1998). The null hypothesis - that the mean ERVES is zero - was rejected at the one percent level (t = -12.96; p=0.000). This statistically significant negative mean effect size suggests a negative relationship between exchange rate variability and trade. Yet, because the ERVES are t-values, the mean ERVES suggests that in the typical regression the coefficient on exchange rate variability falls short of conventionally accepted levels of statistical significance. Moreover, this negative effect is not uniform across the literature. The observed ERVES ranges from -22.00 to 14.77, which suggests considerable variation around the mean. However, if the differences among observed ERVES are random sampling effects, then under the null the standard deviation of the ERVES distribution should be one ($\sigma_{ERVES} = 1$); otherwise, in the presence of systematic variation from the mean, the standard deviation exceeds one ($\sigma_{ERVES} > 1$). The null was rejected ($\chi^2 = 2{,}441$; p=0.000). This result supports the alternative hypothesis that the variations of the observed ERVES around their mean are the product of systematic differences in the design of the primary studies. MRA is a method to analyse the specification characteristics that determine differences among the observed ERVES. Hence, in the following section, we discuss the specification of our meta regression model.

[4] The mean and standard deviation weighted to give each study equal influence on the estimates are, respectively, -1.21 and 2.55.

3.2 Independent variables

The key to explaining variation among observed ERVES is selection of appropriate moderator variables. This selection was guided both by our interpretation of the studies that provide the data for our MRA and by suggestions from the two most recently published narrative literature reviews (McKenzie, 1999; Pugh, et al., 1999). Moderator variables are constructed as dummy variables (i.e., one for studies with a particular characteristic; otherwise zero). First, we explain those that are needed to account for different definitions of both the dependent variable (trade flows) and the independent variable of interest (exchange rate variability).

Some researchers argue that analysis of aggregate trade flows is misleading (McKenzie 1999) and, instead, use bilateral trade flows. However, because of near perfect multicollinearity between the moderator variable for bilateral trade flows and the moderator variable for bilateral exchange rates (BILATERAL), we use the latter to capture the effect on the ERVES of both of these study characteristics. A few studies examine the impact of exchange rate variability on sectoral trade flows. Hence, we construct a moderator variable for sectoral trade flows (SECTALT) with aggregate trade flows as the benchmark. Researchers also have to make a choice between the effects of exchange rate variability on export supply and the effects on import demand. Because of differences in the currency of invoicing, levels of risk aversion and elasticities of export supply and import demand, the impact of exchange rate variability is likely to vary. Hence, we construct a moderator variable for import demand (IMPORT), with export supply as the benchmark.

The definition of the independent variable of interest is also contested. There are differences in the literature over both the appropriate exchange rate measure and the appropriate measure of exchange rate variability. The choice between nominal and real exchange rates is related to the choice of high or low frequency exchange rate variations. Over short periods, all prices are more or less known except the nominal exchange rate. However, as the planning horizon of traders is lengthened, the relevant exchange rate becomes that between domestic cost of production and foreign sale prices converted into domestic currency (IMF 1984). Hence, we construct a moderator variable to test the impact of researchers' choice of real exchange rate series (REALER) on the ERVES, with nominal exchange rate data as the benchmark. Pugh et al. (1999) distinguish between studies focussing on high-frequency variability and those focussing on low-frequency variability. This issue is important, because of the different time horizons of business contracts, and correspondingly different hedging possibilities. Since low-frequency exchange rate movements are less subject to hedging (Bodnar, 1997; Cooper, 2000), any mitigating effect will be correspondingly reduced. Hence, we constructed moderator variables to test the impact of researchers' choice of daily, weekly, monthly and annual frequency of exchange rate variability on the ERVES (DAILYER, WEEKLYER, MONTHER and ANNUALER), with the most used frequency (quarter-to-quarter variations) as the benchmark. Studies also differed over the choice of measure to proxy exchange rate uncertainty. The most common measure, the standard deviation of either exchange rate changes or percentage changes, is used as the benchmark. However, we identified 13 alternative measures in the literature (MERV 1-13; see Appendix A for definitions) and so constructed moderator variables to analyse the effect of each of these on the ERVES. Researchers are also divided over the choice between bilateral and effective exchange rates. Hence, a moderator variable for bilateral exchange rates was constructed (BILATERAL), with effective exchange rates as the benchmark. The grounds for different choices between bilateral and effective exchange rates are similar to Cushman's (1986) case for modelling third-country effects. This third-country effect suggests that overall decrease in trade occasioned by increased exchange rate variability will be lower than is likely to be suggested by studies of purely bilateral trade flows, because traders substitute markets with low exchange rate variability for markets with higher variability. Hence, a moderator variable is included for all models that include third-country effects (THIRDCOUN).

We construct moderator variables not only to model different definitions of the dependent and independent variable of interest but also to account for other differences in datasets and model specification. Many studies have used data from within floating exchange rate periods only or from within fixed periods only. The reason is to preclude possible specification bias associated with structural changes in the relationship between exchange rate variability and trade (Pugh and Tyrrall, 2002 and Arize, 1997a). Hence, moderator variables were constructed for studies using only fixed (FIXPER) or floating (FLOPER) periods, with studies using both periods as the benchmark.

The type of country can also influence the trade effects of exchange rate variability. In particular, there are reasons to expect stronger effects on developing economy trade: these include underdeveloped or nonexistent forward markets; and different trade structures, with typically greater dependence on primary products. Hence, we construct moderator variables both for studies focussing solely on trade among developed countries (DC) and for those focussing solely on less developed economy trade (LDC), with studies pooling data on both type of trade as the reference category. In addition, we construct a moderator variable for studies that focus exclusively on US trade flows (US). Possible differences between the impact of exchange rate variability on US trade and the trade of other countries might arise from the ability of US traders to invoice in USD.

There is likewise no consensus over the choice of model. Most studies have employed a conventional utility maximisation approach to analyse the trade effects of exchange rate variability. However, since Abrams (1980) some researchers have argued that a gravity model provides a better explanation of international trade flows; and, hence, that the impact of exchange rate variability on trade should be examined within the gravity framework. Other researchers have specified time series models to estimate conventional models: at first, with lagged independent variables; subsequently, error correction modelling; and, finally, cointegration analysis in the context of error correction modelling. Accordingly, we construct moderator variables to test the influence on the ERVES of a gravity framework (GRAVITY), lagged independent variables (LAGTEST), error-correction modelling (ERRORCOR) and cointegration analysis (LRCOINT), with those studies otherwise estimating conventional utility maximisation models as the benchmark. We also construct moderator variables to investigate the effect on the ERVES of cross-section (CROSS) or panel (POOLED) strategies, with time-series estimation as the benchmark.

Akhtar and Hilton (1984) observed that data on trade flows usually exhibits seasonal patterns. Hence, a moderator variable was constructed for all models using seasonally adjusted data, testing for seasonality, or including seasonal dummy variables (SESONADJ). The coefficients on exchange rate variability in Rose's regressions (2000) were on average estimated with unusually high levels of statistical significance. Accordingly, we constructed a moderator variable for regressions from Rose's study (ROSE). Finally, moderator variables were included for all studies that control for structural breaks (DOCKSTR - including dock strikes, oil shocks, changes in monetary regime and wars) and to control for the possibility that the trade effects of exchange rate variability may change through time (T, which is a continuous variable defined as the mean year of the estimation period).

We also include in the MRA the square root of the degrees of freedom (SqRt_df) from each regression to test for the existence of an authentic empirical effect in the literature rather than mere reflection of publication bias (Stanley 2005). In the present study, theory permits the trade effect of exchange rate variability to be either positive or negative, and neither alternative is excluded by the empirical evidence. If either negative or positive effects dominate, then two conditions are necessary to confirm the existence and the direction of an authentic empirical effect: that a statistically significant relationship between the effect size and the square root of the degrees of freedom exists; and that the relationship has the same sign as the estimated average effect size. In addition, in the presence of the square root of the degrees of freedom, the intercept term may be interpreted as a test for publication bias and, if statistically significant, its estimated coefficient measures the direction and strength of publication bias (Stanley 2005). Hence, non significance constitutes non rejection of the null of no publication bias.

3.3 Model specification

Our benchmark MRA model (following Stanley and Jarrell, 1989) is specified in Equation (1):

$$ERVES_j = Int + \beta\sqrt{DF}_j + \sum \alpha_k Z_{jk} + u_j \qquad (1)$$

where

- $j = 1, \ldots, 835$ indexes the regressions in the literature,
- $k = 1, \ldots, 37$ indexes the moderator variables discussed above,
- $ERVES_j$ is the exchange rate variability effect size – i.e., the reported t-value for the coefficient on exchange rate variability in the j^{th} regression,
- Int is the intercept term,
- DF_j is the degrees of freedom in the j^{th} regression,
- the coefficient β is to be estimated and measures the relationship between the square root of DF_j and the effect size,
- Z_{jk} are k moderator variables, which reflect the main data and specification characteristics of the j^{th} regression,
- α_k are k coefficients to be estimated, each of which measures the effect of a moderator variable on the effect size,
- and u_j is the usual regression residual.

4 Results

We check the robustness of our results with respect to estimation technique by reporting not only OLS but also weighted least squares (WLS) and cluster-robust estimates. There are two potential problems with OLS estimation. First, there is wide variation in the number of results reported by each study: while the mean number of results per study is 14.15, the range is from one to 54. Weighting studies reporting large numbers of results more heavily than studies reporting fewer may distort MRA results (Jarrell and Stanley, 1990). Accordingly, to adjust for disparity in the number of reported results, we weight each result from a particular study by the inverse of the number of results reported in that study, so that each study is equally weighted, and estimate the MRA model by Weighted Least Squares (WLS). The second problem is that reported results in MRA are not sampled independently, but are sampled in groups (most studies report a group of results). Accordingly, we add cluster-robust estimates to both our OLS and our WLS results.[5] For these two reasons, in Table 3 we report four sets of results: OLS; weighted least squares (WLS), cluster-robust linear regression; and cluster-robust WLS. In all cases, t-statistics and p-values reflect robust standard errors.

We also check the robustness of our results with respect to model specification. Accordingly, we estimated a fully specified model with all the variables discussed in Section 3.2 and then two successively more parsimonious versions. Our final parsimonious model is reported in Table 3; the full and an intermediate parsimonious model are available on request. Estimates from the fully specified model cannot be regarded as valid, because both the unweighted and the weighted models are misspecified with respect to functional form and display evidence of substantial collinearity. Accordingly, five variables were deleted: “LAGTEST”, “MERV4” and “MERV9” to ensure adequate specification with respect to functional form; and

[5] This procedure relaxes the assumption of independence between observations within the same group, requiring only that observations be independent between groups, and produces “correct” standard errors ‘even if the observations are correlated’ (StataCorp, 2003; see also Deaton, 1997, pp.73-78 and Baum et al., 2003).

"ROSE" and "DC" to reduce collinearity to conventionally acceptable levels. Finally, we deleted five more variables that in the first parsimonious model were consistently estimated with a t-statistic of less than one. Throughout this testing down procedure, we found that no observations exerted undue leverage, while Cameron and Trivedi's test (reported) was unable to reject the null hypotheses of no non-normal skewness or kurtosis (although we note one borderline result at the conventional five percent level).

Table 3: MRA results for the final (second) parsimonious model (835 observations from 58 studies)

The adjusted R^2 measures are within the range typically reported by MRA studies (see Table 2; also Stanley, 2005, pp.319 and 332). Across all estimation methods in the two parsimonious models, according to standard criteria, variance inflation analysis suggests that collinearity is not a problem; moreover, the Ramsey RESET test rejects the null of omitted variables or incorrect functional form at all conventional levels of significance. Standard diagnostic tests establish that the baseline OLS model is well specified as a statistical model with respect to normality and heteroskedasticity; however, following common practice in MRA, we report robust standard errors.

MRA requires additional diagnostic tests to distinguish between authentic empirical effects and the consequences of publication bias. MRA literature (Stanley, 2005) distinguishes between publication bias that is directional (Type 1) and publication bias that merely favours statistical significance regardless of sign (Type 2). We have already noted the a priori grounds on which Type 1 publication bias is less likely to be present in this study than in most MRAs; namely, with respect to the trade effects of exchange rate variability, theory does not privilege one direction over another, while published empirical studies report positive, negative, zero and inconclusive effects (see Table 1). The number of studies reporting zero effects may also suggest that Type 2 publication bias is less likely in this than in other empirical literatures. The following testing procedure follows Stanley (2005, p.339) and constitutes a 'conservative approach to the identification of an empirical effect'.

To test for both Type 1 publication bias and for an underlying 'genuine empirical effect, irrespective of publication bias' (Stanley, 2005, p.328; see also pp. 320-23 and 329-332), we embed the "Funnel asymmetry precision effect" test within each of our models reported in Table 3, as well as in the full and intermediate models not reported, by including among the independent variables the square root of the degrees of freedom (SqRt_df). In the full and parsimonious models alike, three of the four estimation methods (the exception in each case being simple OLS) result in intercept terms (_cons) not significantly different from zero at conventional levels, which suggests non rejection of the null of no publication bias. Moreover, in each case, the coefficient on the square root of the degrees of freedom is negative. In both parsimonious models the coefficients on the square root of the degrees of freedom (SqRt_df) are estimated as -0.02 in the two unweighted regressions and as -0.04 in the two weighted regressions; moreover, from these eight estimated coefficients, only the two from the cluster-robust least squares estimator fail to achieve statistical significance at conventional levels. Because the ERVES is the t-value on the exchange rate variability coefficient in each regression in our dataset, this result suggests that studies with larger samples on average are more likely to find a statistically significant negative relationship between exchange rate variability and trade.[6] This is consistent with a genuine empirical effect (Stanley, 2005, p.332). Sampling theory predicts that, holding all other variables constant, a quadrupling of degrees of freedom doubles the effect size. For example, our weighted meta regression coefficient of -0.04 suggests that the *t*-statistic on the measure of exchange rate variability in a trade regression estimated with 100 degrees of freedom will be -0.4 (= $-0.04\sqrt{100}$); -0.8 with 400 degrees of freedom (= $-0.04\sqrt{400}$); and so on. At the unweighted mean degrees of freedom (1077.35; SD = 4151.76) the predicted *t*-statistic is -0.76; and at the weighted mean (430.44; SD = 2432.29) -0.91 (both calculated using the exact weighted and unweighted coefficients). However, considerable variation around such predicted values is caused by study characteristics modelled by the moderator variables, which are discussed below.[7]

Type 2 publication bias is manifested as 'an excessive likelihood of reporting significant results' (Stanley, 2005, p.318). The corresponding test was implemented for both parsimonious models by substituting the absolute value for the actual value of our dependent variable (ERVES). In this case, a significant intercept term (_cons) would indicate Type 2 publication bias (Stanley, 2005, pp.325 and 332). (For reasons of space, these results are not reported in full; they are available on request.) In the first parsimonious model, only the intercept in the baseline least squares regression proved to be significant (p=0.03); the three remaining estimators yielded intercept

[6] The 573 *t*-values estimated from 100 or fewer degrees of freedom have a mean of -0.75 (SD=2.02); the 114 estimated from between 101and 500 degrees of freedom have a mean of -1.08 (SD=2.60); and the 148 estimated from more than 500 degrees of freedom have a mean of -3.66 (SD=4.56).

[7] In bivariate regressions of ERVES on a constant and the square root of the degrees of freedom (SqRt_df), the R^2 measures are, respectively, 0.27 (unweighted) and 0.16 (weighted). In comparison, the R^2 measures reported in Table 3 are, respectively, 0.48 and 0.35.

terms with a uniform lack of statistical significance ($p \geq 0.17$). In the second parsimonious model, the intercept terms were uniformly insignificant ($p \geq 0.14$). Following a suggestion in Stanley (2005) the standard errors were bootstrapped but without making any noteworthy difference to this pattern of results. Hence, the preponderance of the evidence does not indicate the presence of Type 2 publication bias.

Taken together, these tests suggest that the negative mean ERVES in the empirical literature (a *t*-value of -1.31), although small, reflects a genuine negative relationship between exchange rate variability and international trade rather than publication bias. Given that both theory and empirical findings on the trade effects of exchange rate variability permit both negative and positive effects, these findings are consistent with the understanding in the meta-regression literature that 'publication bias will be less problematic whenever there are countervailing research propositions' (Stanley, 2005, p.335). We now turn to the estimated effects of the moderator variables. We restrict our discussion to those variables that display a consistently significant influence on the effect size across all specifications (while, because of statistical misspecification in the full model, giving preference to the parsimonious models) and all different approaches to estimation.

The consistently negative and, with one exception, significant coefficient on real exchange rate variability (REALER) supports the view that forward markets have a role in reducing exchange rate uncertainty. If a significant negative trade effect is more likely to be discovered by analysing real variability than by analysing nominal variability, this might be because real variability diverges from nominal variability only over long periods (Taylor, 1995) and thus cannot be hedged. This interpretation is supported by the predominantly negative (six from eight estimates in the parsimonious models) and significant (half of all estimates) effect of year-to-year variability (ANNUALER), which is much less subject to hedging than high-frequency exchange rate variability. In both parsimonious models, the consistently negative and predominantly significant coefficient on trade among less developed countries (LDC) also points to the importance of hedging. Underdeveloped or nonexistent forward markets for LDC currencies, together with capital movement constraints in the LDCs, reduce the possibility and increase the price of hedging, thereby causing higher exposure to exchange rate uncertainty and a correspondingly greater trade effect.

The consistently and significantly negative coefficients measuring the effect of gravity (GRAVITY), cross-section (CROSS), cointegration (LRCOINT) and, to a lesser extent, error-correction (ERRORCOR) modelling suggest that these are all much more likely to discover statistically significant negative trade effects and less likely to discover positive effects than other modelling strategies. However, while there is little distinction to be made between the implications of cross-section and time-series studies, both contrast with the uniformly insignificant effect of panel estimation (POOLED). Together, these results suggest that choice of modelling strategy accounts for some of the wide variation of results in this literature. Moreover, the consistently and significantly negative results for dummy variables used to model structural breaks (DOCKSTR) in time series data demonstrate that these are important controls for estimating the trade effects of exchange rate variability.

Finally, of the 13 moderator variables used to distinguish proxy measures of exchange rate uncertainty, only five yield estimated coefficients that are both consistently signed and with at least two from the four reported in Table 3 significant at the five percent level. MERV11 and MERV8 display positive effects, indicating that studies employing these definitions are less likely to detect a statistically significant negative relationship between exchange rate variability and trade. In contrast, MERV3, MERV7 and, to a lesser extent, MERV13 display negative effects, indicating that studies employing these definitions are more likely to detect a significant negative relationship. However, these measures are typically used in only a few studies and observations.[8] Together with the non-significant effects of the other seven alternative measures, these results suggest that alternative measures have so far added little to the conventional approach represented by the reference category.

The existence of an earlier Working Paper (available on request) using the same modelling strategy enables robustness also to be investigated with respect to the sample. The earlier study was based on a smaller sample of 40 papers (544 observations). Accordingly, to address the corresponding possibility of biases resulting from having in effect a very large sample rather than the complete population, we treat the databases of our earlier and present studies as different size samples. By comparing the results from our earlier and the present studies, we conclude that the evidence reported above on publication bias, the role of hedging and the influence of various modelling strategies is robust to a major enlargement of the

[8] MERV11 is used in one study with 17 observations; MERV8, three and 11, respectively; MERV3, three and 24; MERV7, two and 37; and MERV13, one and six.

sample, while the effects of different proxy measures of exchange rate uncertainty are not.

5 Conclusion

We applied MRA to the empirical literature on the trade effects of exchange rate variability. 58 papers published between 1978 and 2003 provide 835 usable estimates of our effect size, which is the t-value of the estimated coefficient measuring the trade effect of exchange rate variability.

The theoretical literature does not yield an unambiguous prediction on how exchange rate variability affects trade, while the corresponding empirical literature has yielded the full range of possible results and thus has not generated consensus. MRA enables overall assessment of precisely this kind of diverse and contradictory empirical literature. Simple "vote counting" (Table 1) and the negative mean effect size (-1.31) both suggest *a negative relationship between exchange rate variability and trade*. Moreover, MRA finds little evidence of publication bias together with mainly positive evidence that this relationship is an authentic empirical effect. Yet the same evidence also suggests that *this negative relationship is not robust*: the vote count is not overwhelming; the average effect falls short of conventionally accepted levels of statistical significance; and MRA identifies sources of variability and corresponding non-robustness. Accordingly, our main conclusion is that *the empirical literature on exchange rate variability and trade reveals a modestly negative relationship with pronounced heterogeneity*.

This heterogeneity is consistent with Gagnon (1993, p.279) who calibrates a theoretical model of the trade effects of exchange rate variability and finds that not only is the negative effect of increasing variability on the level of trade small but also that the effect 'would not be statistically significant in the sample sizes typically available to researchers'. Lack of precision of estimates from small sample studies helps to explain the wide range of findings in the literature; indeed, 68.62 percent of the reported regressions analysed in this study are estimated from samples of 100 or fewer observations, which is the number that Gagnon uses as his benchmark. Accordingly, our finding that the relationship between sample size (degrees of freedom) and effect size is negative and statistically significant is consistent both with Gagnon's (1993) insights and with Stanley's (2005) criterion from the meta-regression literature for an authentic empirical regularity.

Two recent studies have suggested that the negative trade effect of exchange rate variability is 'by no means a robust, universal finding' (Clark et al., 2004, p.6; see also Solakoglu, 2005). This MRA is able more conclusively to establish that *the trade effects of exchange rate variability are highly conditional*. This finding may be instructive for policy by providing evidence that the average trade effects suggested by this literature are not sufficiently robust to generalise across countries.

This MRA not only confirms that the relationship between exchange rate variability and trade is highly conditional, but also identifies factors that help to explain why estimated trade effects vary from significantly negative to significantly positive. One of these suggests policy implications and new lines of enquiry.

Modelling strategy may substantially influence estimates of the trade effects of exchange rate variability: in particular, gravity models, both cross sectional and modern time series approaches and the use of bilateral exchange rates and trade flows all make more likely the estimation of a significantly negative trade effect. Much of the research effort in this literature has been devoted to developing and testing proxy measures of exchange rate uncertainty as alternatives to the standard deviation of exchange rate changes. However, most of these alternative measures do not robustly influence the statistical significance of estimated trade effects in a way that differs from the conventional measure and none are widely used. These results are consistent with Brodsky (1984) who critically reviewed an earlier literature on the measurement of exchange rate variability and concluded that the standard deviation is the appropriate measure. So far at least, innovatory measurement of exchange rate variability does not appear to have yielded interesting new results on the determinants of international trade. Our results indicate that a statistically significant negative impact of exchange rate variability is more likely when it is beyond the range of forward markets. In particular, the substantially more negative effect associated with LDC trade connects our investigation with the large literature connecting financial development, trade and growth. Further investigation of the impact of hedging on trade may well be a fruitful source of ideas for trade promotion.

To check the robustness of our estimated influences on effect size and of our tests for publication bias and an authentic empirical effect, we make a case for applying different estimation techniques together with a standard testing down procedure. The presence in MRA databases of studies typically reporting varying numbers of interdependent results suggests the use of both weighted and cluster-robust estimators to complement OLS estimation. Similarly, because MRA models are specified by separate judgements about potential moderator variables rather than being derived from theory, specification may be more arbitrary than is the norm in econometric studies in economics. If so, then Leamer and Leonard's (1983) and Leamer's (1985) strictures concerning the robustness of regression estimates may apply with particular force to MRA. Although we make no attempt to enact Leamer's methods, it is in their spirit that we recommend robustness checking across a full model including all moderator variables and successively more parsimonious specifications. In addition, where it is difficult to identify the entire population either of relevant studies or of relevant results for MRA, we suggest that it may be instructive to check the robustness of meta-regression estimates with respect to different samples.

Acknowledgements

The authors acknowledge helpful suggestions from Tom Stanley and other participants at the International Colloquium on Meta-Analysis in Economics, Sønderborg (September 2007). In addition, the paper was greatly improved by guidance from our two anonymous referees. The authors alone are responsible for shortcomings.

References

Abbott, A., Darnell, A., Evans, L., 2001. The Influence of Exchange Rate Variability on UK Exports. *Applied Economic Letters* 8, 47--49.

Abrams, R., 1980. International Trade Flows Under Flexible Exchange Rates. *Federal Reserve Bank of Kansas City Economic Review* 65, 3--10.

Akhtar, M., A., Hilton, R., S., 1984. Exchange Rate Uncertainty and International Trade: Some Conceptual Issue and New Estimates for Germany and the United States. *Federal Reserve Bank of New York Research Papers* 8403.

Anderson, M., Garcia, P., 1989. Exchange Rate Uncertainty and the Demand for US Soybeans, *American Journal of Agricultural Economics* 71, 721--29.

Aristotelous, K., 2001. Exchange-Rate Volatility, Exchange-Rate Regime and Trade Volume: Evidence from the UK-US Export Function (1889-1999). *Economics Letters*, 72, 87--94.

Arize, A., C., 1995. The Effect of Exchange Rate Volatility on US Exports. *Southern Economic Journal* 62, 34--43.

Arize, A., C., 1996a., Real Exchange Rate Volatility and Trade Flows: The Experience of Eight European Economies. *International Review of Economics and Finance* 5, 187--205.

Arize, A., C., 1996b. The Impact of Exchange Rate Uncertainty on Export Growth: Evidence from Korean Data. *International Economic Journal* 10, 49--60.

Arize, A., C., 1997a. Conditional Exchange Rate Volatility and Trade Flows: The Experience of Eight European Economies. *Southern Economic Journal* 64, 235--253.

Arize, A., C., 1997b. Foreign Trade and Exchange rate Risk in G-7 Countries. *Review of Financial Economics* 6, 95--112.

Arize, A., C., 1998. The Effects of Exchange Rate Volatility on U.S. Imports: An Empirical Investigation. *International Economic Journal* 12, 31--40.

Arize, A., C., Osang, T., Slottje, D., J., 2000. Exchange rate Volatility and Foreign Trade: Evidence from Thirteen LDC's. *Journal of Business and Economic Statistics* 18, 10--17.

Arize, A., C., Shwiff, S., S., 1998. Does Exchange-Rate Volatility Affect Import Flows in G-7 Countries? Evidence from Cointegration Models. *Applied Economics* 30, 1269--1276.

Assery, A., Peel, D., A., 1991. The Effect of Exchange Rate Volatility on Exports: Some new Estimates. *Economic Letters* 37, 173--177.

Bahmani-Oskooee, M., Payesteh, S., 1993. Does Exchange Rate Volatility Deter Trade Volume of LDC's ? *Journal of Economic Development* 18, 189--205.

Bailey, M., J., Tavlas, G., S., Ulan, M., 1986. Exchange Rate Variability and Trade Performance: Evidence for the Big Seven Industrial Countries. *Weltwirtschaftliches Archiv* 122, 467--477.

Bailey, M., J., Tavlas, G., S., Ulan, M., 1987. The Impact of Exchange Rate Volatility on Export Growth: Some Theoretical Considerations and Empirical Results. *Journal of Policy Modelling* 9, 225--243.

Baum, C., Schaffer, M., Stillman, S., 2003. Instrumental variables and GMM: Estimation and Testing. *Boston College Department of Economics, Working Paper* 545.

Bini-Smaghi, L., 1991. Exchange Rate Variability and Trade: Why Is It So Difficult to Find Any Empirical Relationship? *Applied Economics* 23, 927--935.

Bodnar, G., 1997. Exchange rate exposure and market value, in: *Financial Times*, Mastering Finance Series, 1997, 4, p. 2. Reprinted in: *Mastering Finance*, 1998. FT Pitman, London.

Brodsky, D., 1984. Fixed Versus Flexible Exchange Rates and the Measurement of Exchange Rate Instability. *Journal of International Economics* 16, 295--306.

Caporale, T., Doroodian, K., 1994. Exchange rate Variability and The Flow of International Trade. *Economic Letters* 46, 49--54.

Card, D. & Krueger, A.B. 1995, Time Series Minimum Wage Studies: A Meta-analysis, *American Economic Review*, Vol. 85, pp. 238-243.

Chan, P., Wong, J., 1985. The Effect of Exchange rate variability on Hong Kong's Exports. *Hong Kong Economic Papers* 10, 27--39.

Chou, W., L., 2000. Exchange Rate Variability and China's Exports. *Journal of Comparative Economics* 28, 61--79.

Chowdbury, A., R., 1993. Does Exchange Rate Volatility Depress trade Flows? *The Review of Economics and Statistics* 75, 45--63.

Clark, P., Tamirisa, N., Wei, S.-J., Sadikov, A. and Zeng, L. (2004). Exchange Rate Volatility and Trade Flows: Some New Evidence. International Monetary Fund, Occasional Paper 235 (May).

Cooper, R., 2000. Towards a Common Currency. *International Finance* 3, 287--308.

Cushman, D., O., 1983. The Effect of Real Exchange Rate Risk on International Trade. *European Economic Review* 15, 45--63.

Cushman, D., O., 1986. Has Exchange Risk Depressed International Trade? *The Impact of Third Country Exchange Risk. Journal of International Money and Finance* 5, 361--379.

Cushman, D., O., 1988. US Bilateral Trade Flows and Exchange Rate Risk during the Floating Period. *Journal of International Economics* 24, 317--330.

Daly, K., 1996. The Effect of Exchange Rate Volatility on the Volume of Japan's Bilateral Trade. *The Singapore Economic Review* 41, 23--39.

De Grauwe, P., 1988. Exchange Rate Variability and Slowdown in Growth of International Trade. *IMF Staff Papers* 35, 63--84.

De Grauwe, P., Bellfroid, B., 1987. Long-run Exchange Rate Variability and International Trade, in: Arndt, S., Richardson, J.D., *Real- financial Linkages among Open Economies*. The MIT Press, London, pp. 193--212.

Deaton, A., 1997. *The Analysis of Household Surveys*. The John Hopkins University Press, Baltimore Maryland.

Dell'ariccia, G., 1999. Exchange Rate Fluctuations and Trade Flows: Evidence from the European Union. *International Monetary Fund Staff Papers* 46, 315--334.

Dellas, H., Zilberfarb, B., 1993. Real Exchange Rate Volatility and International Trade: A Reexamination of the Theory. *Southern Economic Journal* 59, 641--647.

Dhanani, A., Groves, R., 2001. The management of strategic exchange risk: evidence from corporate practices. *Accounting and Business Research* 31, 275--290.

Doyle, E., 2001. Exchange Rate Volatility and Irish-UK Trade, 1979-1992. *Applied Economics* 33, 249--265.

Fountas, S., Aristotelous, K., 2003. Does the Exchange Rate Regime Affect Export Volume? Evidence from Bilateral Exports in US-UK Trade: 1900-98. *The Manchester School* 71, 51--64.

Gagnon, J., 1993. Exchange rate variability and the level of international trade. *Journal of International Economics* 34, 269--287.

Giorgioni, G., Thompson, J., L., 2002. Which Volatility? The Case of the Exports of Wheat. *Applied Economics Letters* 9, 681--684.

Görg, H. and Strobl, E. (2001) Multinational Companies and Productivity Spillovers: A Meta-Analysis, *Economic Journal*, 723-739.

Gotur, P., 1985. The Effect of Exchange Rate Volatility on Trade: Some Further Evidence. *IMF Staff Papers* 32, 475--521.

Grobar, L., 1993. The Effect of Real Exchange Rate Uncertainty on LDC Manufactured Exports, *Journal of Development Economics* 41, 367--376.

Gros, D., 1987. Exchange Rate Variability and the Foreign Trade in the Presence of Adjustment Costs. *CESP Working Papers* 8704 (Univesite Catholique de Louvain).

Hassan, M., K., Tufte, D., R., 1998. Exchange Rate Volatility and Aggregate Export Growth in Bangladesh. *Applied Economics* 30, 189--201.

Holly, S., 1995. Exchange Rate Uncertainty and Export Performance: Supply and Demand Effect. *Scottish Journal of Political Economy* 42, 381--391.

Hooper, P., Kohlhagen, S., W., 1978. The Effect of Exchange Rate Uncertainty on the Price and Volume of International Trade, *Journal of International Economics* 8, 483--511.

IMF: International Monetary Fund, Research Department (1984) Exchange Rate Volatility and World Trade. *International Monetary Fund, Occasional Papers* 28.

Jarrell, S., B., Stanley, T., D., 1990. A Meta-Analysis of the Union-Nonunion Wage Gap. *Industrial and Labor Relations Review* 44, 54--67.

Kenen, P., B., Rodrik, D., 1986. Measuring and Analyzing the Effect of the Short-term Volatility in the Exchange Rates. *Review of Economics and Statistics* 68, 311--315.

Kiheung, K., WooRhee, L., 1996. The Impact of Korea's Exchange Rate Volatility on Korean Trade, *Asian Economic Journal* 10, 45--60.

Klein, M., W., 1990. Sectoral Effects of Exchange Rate Volatility on United States Exports. *Journal of International Money and Finance* 9, 299--308.

Kroner, K., Lastrapes, W., 1993. The Impact of Exchange Rate Volatility on International Trade. *Journal of International Money and Finance* 12, 293--318.

Kumar, R., Dhawan, R., 1991. Exchange Rate Volatility and Pakistan's Exports to the Developed World, 1974-85. *World Development* 19, 1225--1240.

Leamer, E., 1985. Sensitivity Analyses Would Help. *American Economic Review* 75(3), 308--313.

Leamer, E., Leonard, H., 1983. Reporting the Fragility of Regression Estimates. *Review of Economics and Statistics* 65, 306--317.

Lee, J., 1999. The Effect of Exchange Rate Volatility on Trade in Durables. *Review of International Economics* 7, 189--201.

McKenzie, M., D., 1998. The Impact of Exchange Rate Volatility on Australian Trade Flows. *Journal of International Financial Markets, Institutions and Money* 8, 21--38.

McKenzie, M., D., 1999. The Impact of Exchange Rate Volatility on International Trade Flows. *Journal of Economic Surveys* 13, 71--106.

McKenzie, M., D., Brooks, R., D., 1997. The impact of Exchange Rate Volatility on German – US Trade Flows. *Journal of International Financial Markets, Institutions and Money* 7, 73--87.

Medhora, R., 1990. The Effect of Exchange Rate Variability on Trade: the case of West African Monetary Union's Imports. *World Development* 18, 313--324.

Perée, E., Steinherr, A., 1989. Exchange rate uncertainty and foreign trade. *European Economic Review* 33, 1241--1264.

Pozo, S., 1992. Conditional Exchange Rate Volatility and the Volume of International Trade: Evidence from The Early 1990's. *Review of Economics and Statistics* 74, 325--329.

Pradhan, K., H., 1988. Exchange Rate Variability of the Rupee and India's Exports. *Margin* 20, 28--47.

Pugh, G., Tyrrall, D., 2002. Will the single currency promote intra-European trade? *European Business Journal* 14, 150--157.

Pugh, G., Tyrrall, D., Tarnawa, L., 1999. Exchange Rate Variability, International Trade and the Single Currency Debate: a survey, in: Wim M., (Eds.), *Economic Policy in the European Union*, Edward Elgar, Cheltenham, pp. 9--25.

Qian, Y., Varangis, P., 1994. Does Exchange Rate Volatility Hinder Export Growth. *Empirical Economics* 19, 371--396.

Rose, A., 2000. One Money, One Market: Estimating the Effect of Common Currencies on Trade. *Economic Policy* 30, 9--45.

Rose, A., 2004. A Meta-Analysis of the Effect of Common Currencies on International Trade. *NBER Working Paper Series*, Working Paper 10373.

Rose, A., K., Stanley, T., D., 2005. A Meta-Analysis of the Effect of Common Currencies on International Trade. *Journal of Economic Surveys* 19, 347--366.

Sauer, C., Bohara, A., K., 2001. Exchange Rate Volatility and Exports: Regional Diferences between Developing and Industrialized Countries. *Review of International Economics* 9, 133--152.

Savvides, A., 1992. Unanticipated Exchange Rate Variability and the Growth of International Trade. *Weltwirtschaftliches Archiv* 128, 446--463.

Sekkat, K., 2001. On The Aggregate Impact of Exchange Rate variability on EU Trade. *German Economic Review* 2, 57--78.

Smit, B., W., 1991. The Variability of the Rand and South African Exports. *Journal for Studies in Economics and Econometrics* 15, 19--29.

Solakoglu, M., 2005. Exchange Rate Volatility and Real Exports: A Sensitivity Analysis. *Journal of Economic and Social Research* 7(1), 1--30.

Stanley, T., D., 1998. New Wine in Old Bottles: A Meta Analysis of Ricardian Equivalence. *Southern Economic Journal* 64, 713--727.

Stanley, T., D., 2001. Wheat from Chaff: Meta – Analysis as Quantitative Literature Review. *Journal of Economic Perspectives* 15, 131--150.

Stanley, T., D., 2005. Beyond Publication Bias. *Journal of Economic Surveys* 19, 309--345.

Stanley, T., D., Jarrell, S., B., 1989. Meta –Regression Analysis: A Quantitative Method of Literature Surveys. *Journal of Economic Surveys* 3, 161--171.

StataCorp (2003) *STATA User's Guide*. College Station, Texas: Stata Corporation.

Stokman, A., 1995. Effect of Exchange Rate Risk on Intra-EC Trade. *De Economist* 143, 41--54.

Taylor, M. (1995) Exchange rate Modelling and Macro Fundamentals, *British Review of Economic Issues*, Vol.17, No.42 (June), 1-42.

Thursby, J., G., Thursby, M., C., 1987. Bilateral Trade Flows, the Linder Hypothesis, and Exchange Risk. *Review of Economics and Statistics* 69, 488--495.

Appendix A: Measures of exchange rate (ER) variability (1; otherwise 0)

MERV1 = 1 if absolute values of ER percentage changes

MERV2 = 1 if average absolute values of ER percentage changes

MERV3 = 1 if absolute or squared differences between previous forward and current spot rates

MERV4 = 1 if the moving standard deviation of ER changes or percentage changes

MERV5 = 1 if the standard deviation of ERs from an ER trend equation

MERV6 = 1 if the standard deviation of ERs from a n-order autoregressive equation

MERV7 = 1 if long-run uncertainty; Perée and Steinherr's (1989) V and U measures

MERV8 = 1 if squared residuals from an ARIMA model

MERV9 = 1 if conditional variance calculated by an ARCH or GARCH model

MERV10 = 1 if variance calculated by a LM (linear moment) model

MERV11 = 1 if the variance of the ER around its trend prediction ($\ln e_t = \varphi_0 + \varphi_1 t + \varphi_0 t^2 + \varepsilon_t$)

MERV12 = 1 if unanticipated changes in ERs (used by Savvides, 1992)

MERV13 = 1 if information contained in forward exchange rate concerning exchange rate expectations (used by Cushman, 1988)

Table 1: Econometric studies on the trade effects of exchange rate variability (1978-2003)

	Study	Negative effect	No effect	Positive effect	Not conclusive
1.	Hooper & Kohlhagen (1978)	0	1	0	0
2.	Abrams (1980)	1	0	0	0
3.	Cushman (1983)	1	0	0	0
4.	Akhtar & Hilton (1984)	1	0	0	0
5.	IMF (1984)	0	0	0	1
6.	Gotur (1985)	0	0	0	1
7.	Chan & Wong (1985)	0	1	0	0
8.	Kenen & Rodrik (1986)	1	0	0	0
9.	Bailey, Tavlas & Ulan (1986)	0	1	0	0
10.	Cushman (1986)	1	0	0	0
11.	Bailey, Tavlas & Ulan (1987)	0	0	0	1
12.	De Grauwe & Bellfroid (1987)	1	0	0	0
13.	Thursby & Thursby (1987)	1	0	0	0
14.	Cushman (1988)	1	0	0	0
15.	De Grauwe (1988)	1	0	0	0
16.	Pradhan (1988)	0	0	0	1
17.	Anderson & Garcia (1989)	1	0	0	0
18.	Perée and Steinherr (1989)	1	0	0	0
19.	Klein (1990)	0	0	1	0
20.	Medhora (1990)	0	1	0	0
21.	Bini-Smaghi (1991)	1	0	0	0
22.	Smit (1991)	0	1	0	0
23.	Assery & Peel (1991)	0	0	1	0
24.	Kumar & Dhawan (1991)	1	0	0	0
25.	Pozo (1992)	1	0	0	0
26.	Savvides (1992)	1	0	0	0
27.	Grobar (1993)	1	0	0	0
28.	Bahmani-Oskooee & Payesteh (1993)	1	0	0	0
29.	Chowdbury (1993)	1	0	0	0
30.	Kroner & Lastrapes (1993)	0	0	0	1
31.	Qian & Varangis (1994)	0	0	0	1
32.	Caporale & Doroodian (1994)	1	0	0	0
33.	Arize (1995)	1	0	0	0
34.	Holly (1995)	0	1	0	0
35.	Stokman (1995)	1	0	0	0
36.	Arize (1996a)	1	0	0	0
37.	Arize (1996b)	1	0	0	0
38.	Daly (1996)	0	0	0	1
39.	Kiheung & WooRhee (1996)	0	0	1	0
40.	McKenzie & Brooks (1997)	0	0	1	0
41.	Arize (1997a)	1	0	0	0
42.	Arize (1997b)	1	0	0	0
43.	Arize (1998)	1	0	0	0
44.	Arize & Shwiff (1998)	1	0	0	0
45.	Hassan & Tufte (1998)	1	0	0	0
46.	Mckenzie (1998)	0	0	0	1
47.	Dell'ariccia (1999)	1	0	0	0
48.	Lee (1999)	0	0	0	1

49.	Arize, Osang & Slottje (2000)	1	0	0	0
50.	Rose (2000)	1	0	0	0
51.	Chou (2000)	1	0	0	0
52.	Abbott, Darnell & Evans (2001)	0	1	0	0
53.	Aristotelous (2001)	0	1	0	0
54.	Doyle (2001)	0	0	1	0
55.	Sauer & Bohara (2001)	0	0	0	1
56.	Sekkat (2001)	0	1	0	0
57.	Giorgioni & Thompson (2002)	1	0	0	0
58.	Fountas & Aristotelous (2003)	0	0	1	0
	Total	**33**	**9**	**6**	**10**

Table 2: Number of studies and observations in examples of MRA

	Number of studies	Number of observations	R^2 (or range of R^2)
Card & Kruger (1995)	15	15	0.02 - 0.10 *
Görg & Strobl (2001)	21	25	0.05 - 0.69
Rose and Stanley (2005)	34	754	0.54 - 0.68

* Adjusted R^2

Table 3: MRA results for the final (second) parsimonious model (835 observations from 58 studies)

Dependent variable: Exchange rate variability effect size (t-statistic)		**OLS (robust SEs)**		**Cluster-robust Linear Regression**		**Weighted Least Squares (WLS)**		**WLS (Cluster robust)**	
		Coef.	P>ltl	Coef.	P>ltl	Coef.	P>ltl	Coef.	P>ltl
Intercept	_cons	3.58	0.05	3.58	0.17	2.17	0.27	2.17	0.42
Square root d.o.f.	SqRt_df	-0.02	0.02	-0.02	0.16	-0.04	0.00	-0.04	0.00
Fixed ER regime	FIXPER	0.40	0.26	0.40	0.45	0.17	0.71	0.17	0.84
Less developed country	LDC	-1.23	0.00	-1.23	0.00	-0.71	0.02	-0.71	0.12
US trade only	US	0.44	0.06	0.44	0.22	0.18	0.64	0.18	0.70
Dep. var. : Sector level	SECTALT	-0.58	0.02	-0.58	0.10	-0.69	0.04	-0.69	0.20
Bilateral ER	BILATER	0.82	0.00	0.82	0.01	0.99	0.00	0.99	0.03
Real ER variability	REALER	-0.39	0.06	-0.39	0.13	-1.03	0.00	-1.03	0.03
Daily ER variability	DAILYER	0.46	0.35	0.46	0.34	-0.43	0.45	-0.43	0.52
Monthly ER variability	MONTHER	0.45	0.06	0.45	0.20	-0.30	0.39	-0.30	0.53
Yearly ER variability	ANNUALER	-1.21	0.01	-1.21	0.03	0.09	0.87	0.09	0.92
Gravity model	GRAVITY	-5.52	0.00	-5.52	0.02	-2.89	0.00	-2.89	0.07
Error-correction model	ERRORCOR	-1.33	0.00	-1.33	0.03	-0.46	0.33	-0.46	0.45
Cointegration analysis	LRCOINT	-1.94	0.00	-1.94	0.00	-2.31	0.00	-2.31	0.00
Structural effects	DOCKSTR	-1.38	0.00	-1.38	0.00	-0.92	0.04	-0.92	0.07
Seasonally-adjusted data	SESONADJ	-0.46	0.10	-0.46	0.25	0.38	0.35	0.38	0.55
Third country effect	THIRDCOUN	-0.58	0.10	-0.58	0.06	-0.68	0.14	-0.68	0.27
Cross-section data	CROSS	-1.07	0.01	-1.07	0.05	-1.65	0.00	-1.65	0.02
Different definitions of ER variability: MERV1-13	MERV1	0.56	0.04	0.56	0.08	-0.69	0.15	-0.69	0.41
	MERV3	-1.85	0.00	-1.85	0.05	-2.27	0.00	-2.27	0.02
	MERV5	-0.43	0.44	-0.43	0.35	0.15	0.79	0.15	0.83
	MERV6	-0.99	0.10	-0.99	0.22	0.34	0.47	0.34	0.68
	MERV7	-0.99	0.13	-0.99	0.20	-2.44	0.00	-2.44	0.02
	MERV8	3.32	0.00	3.32	0.00	1.47	0.18	1.47	0.27
	MERV10	0.73	0.30	0.73	0.21	0.38	0.60	0.38	0.49
	MERV11	3.76	0.00	3.76	0.07	2.33	0.00	2.33	0.04
	MERV12	0.64	0.39	0.64	0.10	0.16	0.83	0.16	0.84
	MERV13	-2.13	0.01	-2.13	0.00	-0.79	0.41	-0.79	0.24
Mid-year of sample period	T	-0.04	0.04	-0.04	0.19	-0.02	0.35	-0.02	0.50
No. of observations		835		835		835		835	

Diagnostics

R^2		0.48	0.48	0.35	0.35
F-test		F(28, 806) = 19.22 Prob>F=0.00			
Maximum VIF		5.6	5.6	2.58	2.58
Mean VIF		2.03	2.03	1.66	1.66
Ramsey RESET test using powers of the fitted values of ERVES	Ho: no omitted variables	F(3,803)=1.69 Prob>F=0.17	F(3,803)=1.69 Prob>F=0.17	F(3,803)=1.15 Prob>F=0.33	F(3,803)=1.15 Prob>F=0.33
Cameron & Trivedi's decomposition of Information Matrix test	Ho: homoskedasticity	Chi-sq.158: = 123.54 p = 0.98	n.a.	n.a.	n.a.
Cameron & Trivedi's decomposition of Information Matrix test	Ho: no non-normal skewness	Chi-sq.28: = 22.37 p = 0.76	n.a.	n.a.	n.a.
Cameron & Trivedi's decomposition of Information Matrix test	Ho: no non-normal kurtosis	Chi-sq. 1 = 4.05 p = 0.044	n.a.	n.a.	n.a.